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Thermocatalytic upgrading of heavy oil by iron oxides nanoparticles synthesized by oil-soluble precursors

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ABSTRACT

Thermocatalytic upgrading of heavy crude oil at reservoir temperature and pressure has been studied. The objective of the present work was to investigate the efficiency of the compounds based on iron (iron carbonyls, iron oxide, metallic iron) on thermocatalytic upgrading process of heavy crude oil at reservoir temperature and pressure (5.0 MPa and up to 523.15 K). The viscosity reducing was used as the main parameter for determination of the efficiency of thermocatalytic upgrading. The effect of structure of the catalyst precursor on the composition of SARA fractions after thermal catalytic upgrading of crude oil was analyzed. A destruction of mainly resin fraction was found to occur during thermocatalytic upgrading of heavy crude oil. The composition and structure of catalysts after crude oil upgrading were determined by the X-powder diffraction and SEM methods. An impact of catalyst (Fe_3O_4) particle size on the efficiency of crude oil thermocatalytic upgrading process was revealed.

1. Introduction

The recovery of heavy crude oil across the world grows due to the severe depletion of traditional light oil reserves. Heavy crude oils and bitumens present about a quarter of total hydrocarbon resources (Head et al., 2003; Speight, 2006). Russia along with Venezuela and Canada own largest discovered deposits of heavy crude oil in the world (Myer et al., 2007). A third part of heavy crude oil and bitumen reserves of Russia is located in Tatarstan, mainly in the Ashal'cha oilfield. The production of hydrocarbons from this oilfield is limited by high viscosity of crude oils and bitumens, which does not allow to use conventional methods of recovery. Therefore, methods and technologies, which can help to reduce viscosity inside the reservoir, have great practical interest. In order to increase the efficiency of heavy oil recovery different technologies can be used like gas injection (Nguyen et al., 2014; Talebian et al., 2014; Hu et al., 2015), thermal treatment (Muraza and Galadima, 2015) and chemical flooding (Fletcher et al., 2015; Chen et al., 2016). However, gas injection or chemical flooding have some limitations for application to recovery of highly viscous crude oil (Abdulbaki et al., 2014). More wide application of thermal methods for increasing efficiency of heavy oil recovery is based on two main reasons. First, increasing of temperature of reservoir helps to decrease significantly viscosity of heavy oil and make this oil mobile. But after extraction from the well this oil becomes even more viscous. Second reason can be based on reduction of resins and asphaltenes fractions and increasing of light fractions like saturated hydrocarbons. In other words, thermal methods allow to make in-situ oil upgrading in the reservoir. However, it is not very easy to achieve this result. Catalysts of various types can significantly improve the oil upgrading processes and increase the efficiency of thermal EOR methods, for example steam injection (Muraza and Galadima, 2015). Clark was among the first who suggest applying catalysts for increasing heavy oil recovery (Clark and Hyne, 1984; Clark et al., 1987a, 1987b). Salts of metals from III and VIII groups were shown to be effective catalysts on simple models of crude oil (thiophene and tetrahydrothiophene). Aluminum compounds were found to be the most effective among them. Catalysts for increasing the heavy crude oil recovery can be roughly divided into six types (Guo et al., 2016): water-soluble catalysts, oil-soluble catalysts, amphiphilic catalysts, minerals and zeolites, solid superacids and dispersed nanoparticles.

Nassar et al. found that higher affinity constant metal oxides to asphaltenes leads to higher catalytic activity of metal compounds (Nassar et al., 2011). Hosseinpour et al. (2014) showed that catalytic activity of metal oxides in the processes of asphaltenes oxidation decreases in the range Co_3O_4 > NiO > CuO ≈ Mn_2O_3 > Fe_2O_3 > WO_3. They made a conclusion on the basis of obtained data that catalytic activity is determined

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